APRIL 18, 1983

CHEMICAL & ENGINEERING

NEWS

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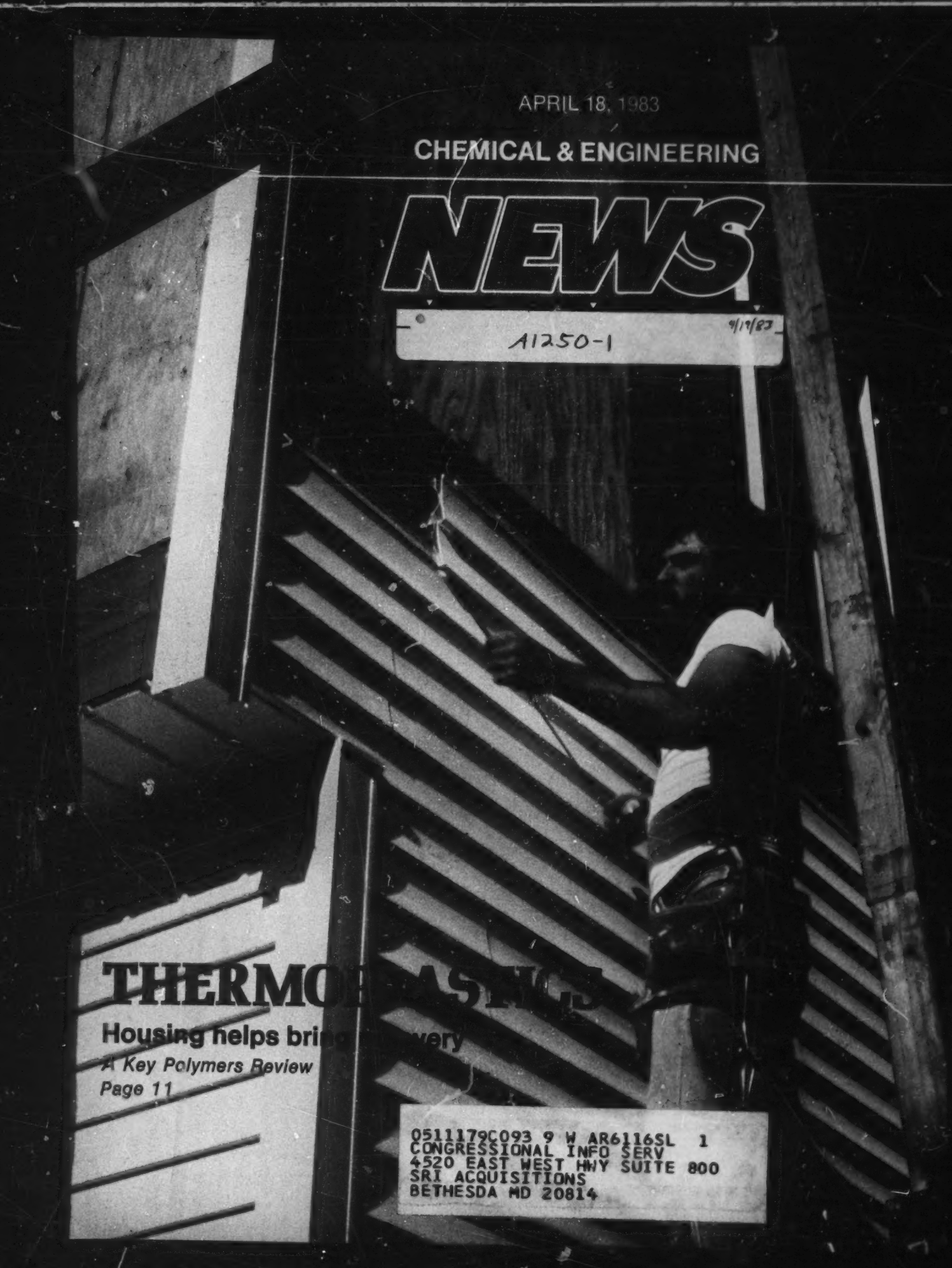

THERMO ASTICS

Housing helps bri very

A Key Polymers Review

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Cover: Workman installs polyvinyl chloride siding on new house. Photo courtesy of B. F. Goodrich Chemical

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CHEMICAL & ENGINEERING NEWS

APRIL 18, 1983

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Cover Story

Uses for thermoplastics, such as in the housing industry, have begun to recover, but so far production outruns demand. **Page 11**

Output of Thermoplastics Turns Up In Modest Recovery

Housing is promising market and others may contribute, but plastics' production gain still may be limited to 6% and plant capacity use to 72%

Bruce F. Greek, C&EN Houston

Relief is sweet. Recovery finally has begun for major U.S. thermoplastics after three years pockmarked by recession. Few in the industry dispute this. But there are big questions about the strength of the upturn for the five leading resins detailed on the following pages—conventional and linear low-density polyethylene, high-density polyethylene, polypropylene, polyvinyl chloride, and polystyrene.

During the fourth quarter of 1982, production and sales of these thermoplastics began heading up after a bad tumble in the second and third quarters. This upturn has continued in the first half of 1983 but is not necessarily gathering strength. The added production to some extent is meeting a real increase in demand, but it also is fattening inventories in anticipation of added sales later this year and in 1984. In other words, production is outrunning real demand at the moment.

Among major markets, housing has picked up strongly from its depths of 1982. However, as far as thermoplastics are concerned, the pickup in this market really has just begun. There is an order lag between the start of a house and sale of the plastic products that go into it—siding, pipe, carpet, furniture, appliances, and other items. So recovery strength for plastics in housing likely will build by 1984. By that time, other parts of the plastics-heavy consumer durables economy may again get moving—for example automobiles, which are nosing up very slowly so far.

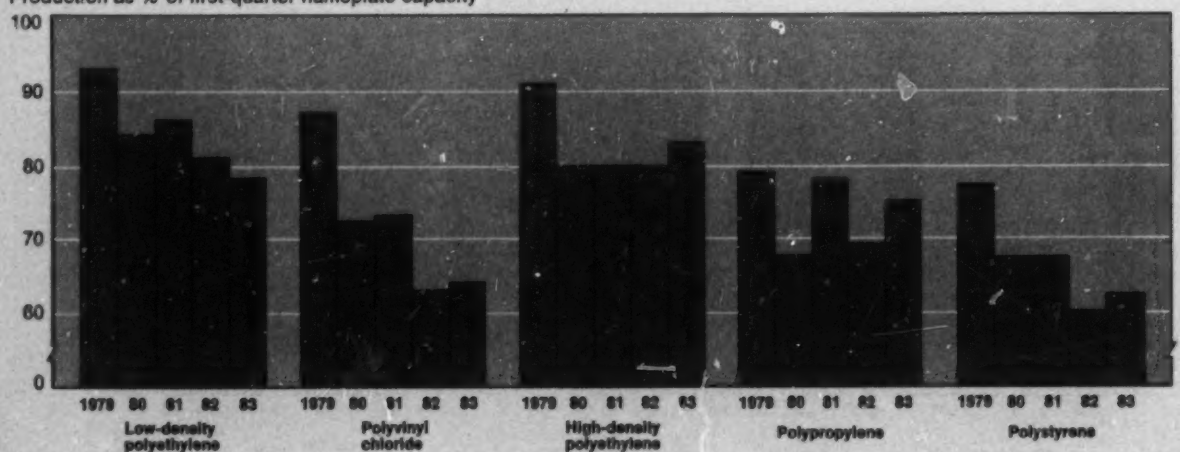
Key Polymers

Disappointment that the current recovery in thermoplastics is not as vigorous as in past recoveries may be inevitable. Slower recovery is the rule now simply because of the maturing of the industry. Double-digit annual growth rates for big-volume thermoplastics are considered a thing of the past. Growth rates of less than 5% per year are the standard forecast now for the 1980s.

For early 1983, recovery on a weight basis (as opposed to dollar basis) appears to be running at about a 6% annual rate. If this pace keeps up, production of the five major thermoplastics could total 25.9 billion lb this year, up 1.5 billion lb from 1982, although still down 3% from 1979's record 26.7 billion lb. The increase could be a third higher if optimists' views prove out that

Capacity use for leading thermoplastics will stay low in 1983

Production as % of first-quarter nameplate capacity



Sources: Industry and C&EN estimates; Society of the Plastics Industry's Committee on Resin Statistics

certain plastics, notably low-density polyethylene and polyvinyl chloride, push 100 million or 200 million lb over forecasts. In that case, 1983 combined production could rise 2 billion lb or 8% over 1982 levels.

The money side of the thermoplastics business, very depressed in 1982, is also looking up. The combination of greater volume and, to a lesser extent, higher prices expected later in 1983 probably will push up the value of 1983 production for the five plastics at least $1 billion, or 14%, from 1982 to a combined $8.3 billion. This is still 13% less than the record $9.5 billion in 1981.

This shortfall says something about plastics' price problems. Average selling prices for the five plastics fell to 30 cents a lb in 1982 from the high of 37 cents in 1981. Prices may inch up to 32 cents a lb in 1983. That would give an increase of about 8% for the year. Even with this increase, plastics won't be very profitable. Significant further increases will be needed this year and later, most industry analysts agree, to generate future investment funds.

Oddly, plant capacity for three of these five thermoplastics—low-density and high-density polyethylene and PVC—still grew in 1982. At the beginning of 1983, capacity for all five totaled 35.7 billion lb a year, up 4% from a year earlier and up 16% from 1979. Since production has gone the other way, capacity use has sagged from 86% in 1979 to 71% in 1982 and about 72% in 1983.

Prospects for capacity growth in 1983 are dimmer. Additions will be coming for low-density and high-density polyethylene and polystyrene but nothing else. Little further capacity expansion seems likely until 1985 or later, except in linear low-density.

In fact, total capacity could sink a bit over the next year as permanent shutdowns outpace additions. Currently, C&EN includes in capacity estimates a lot of plants "temporarily" shut down. Some of these are really down for good and eventually will be deleted from capacity totals.

Some capacity additions still could take place but more subtly through technical advances. Polypropylene is a good example. For some time, catalyst improvements have increased capacity without reactor additions and with very minor additions of other equipment.

Offsetting some of this capacity increase will be a productivity loss incurred in the growing number of polymer grades now offered. Productivity suffers as producers take time to shift process conditions to make these various grades.

Another dent in capacity use arises from plastics' growing dependence on U.S. markets as exports fade because of new plants with low-cost feedstocks starting up in other parts of the world. The decline may begin this year, and exports are expected to be down for all major thermoplastics except polystyrene.

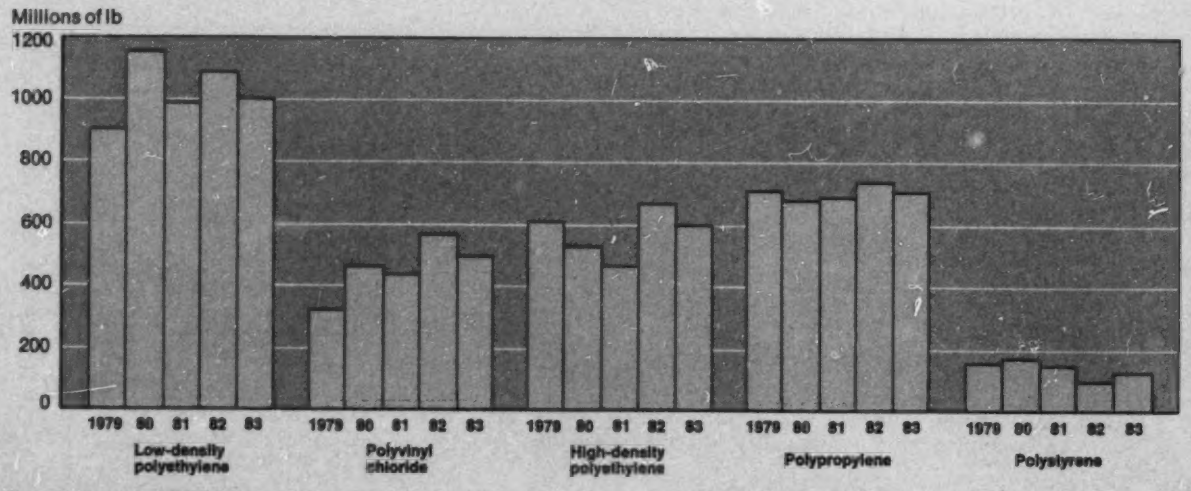
An export drop will hurt. Except for polystyrene, exports of major thermoplastics take 10% or more of production, a significant slice. As the export decline sets in, producers hope to innovate more in U.S. markets to make it up. But producers will be faced later in the 1980s with a rising tide of imports, either as polymers or as fabricated products.

Analysts say this new intensity of competition will bring basic changes in thermoplastics. For example, polymer producers are expected to move further into fabricated products such as the trademark polyethylene bags now on the market. As this move develops, some producers, especially smaller ones, will become more specialized in polymer production.

Such specialization moves also could intensify inter-polymer competition. Past examples include polypropylene varieties taking markets from polystyrene, or high-density polyethylene moving into other plastics' pipe markets.

Although plastics producers may recast their business into specialties eventually, they have a lot of slow-moving commodities to deal with this year. And commodities have to follow the slowly rising trend in the overall economy. It's a time of recovery but also of patience.

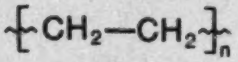
Thermoplastics' previously strong export market will erode in 1983



Sources: Industry and C&EN estimates; Society of the Plastics Industry's Committee on Resin Statistics

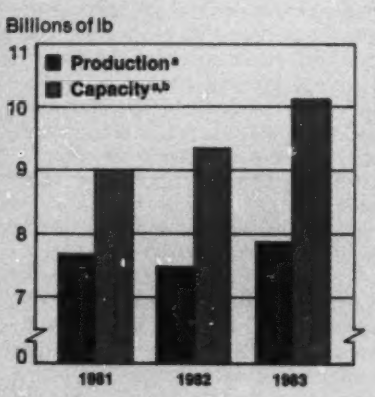
Key Polymers

Low-density polyethylene



- ***Demand rebounding***
- ***Capacity growing***
- ***Prices still low***

PRODUCTION/CAPACITY



a Includes linear low-density polyethylene. b First quarter; includes some shut-down capacity not expected to restart.

HOW MADE

Polymerization of ethylene at high and low pressures aided by catalysts and initiators

MAJOR FABRICATED FORMS (U.S.)

Film, largely for packaging, 65%; coatings 10%; injection molding 5%

FOREIGN TRADE

Exports—large, but may drop to less than 1 billion lb in 1983, imports—less than 40 million lb

PRICES

List prices 28 cents per lb and up; discounts varied and sizable

COMMERCIAL VALUE

$2.5 billion for production, 1983

Low-density polyethylene weathered the recession a little better than expected and will make a run for record U.S. production this year. Producers have enough confidence that capacity expansions continue, mostly in the new, linear low-product type. Still, plant use rates and profitability aren't very good, and the resin's important export market is due for a drop.

Production of low-density polyethylene declined just 3% in 1982 from 1981 to 7.5 billion lb. For 1983, production could bounce back to a new high of 7.9 billion lb, possibly more if linear low-density polyethylene demand reaches optimists' expectations. The record is 7.8 billion lb in 1979.

Both production and sales of this polymer ran above the expected 1983 rate of gain in the latter part of 1982. This unsustainable pace apparently was due to inventory building as interest rates declined and buyers all through the sales chain, from polymer producers to end-product distributors, believed they saw a business pickup. However, analysts say this growth rate, more than 12% for December 1982 over December 1981, can't be maintained for 1983 as a whole.

Plant capacity for low-density polyethylene continued to grow in 1982. This growth equals the net of plant additions for conventional and linear low-density polyethylene minus permanent shutdowns in conventional plants. The largest addition in 1982 was Exxon Chemical's plant at Mont Belvieu, Tex., with capacity of 600 million lb per year of linear low-density polyethylene.

Other additions and subtractions brought total nameplate capacity to 10.1 billion lb as 1983 began, up 9% from a year earlier. Of additions due in 1983, the vast majority will be accounted for by Eastman Chemicals and Mobil Chemical, which are building the last of the conventional low-density plants in the U.S. In addition, process technology improvements will add some linear low-density capacity, and there will be some shifting of older high-density units to make this form of polyethylene.

Not all of this capacity actually is producing. At least 500 million lb currently is shut down and not expected to operate again, at least at the present locations. Probably another 500 million lb, possibly more, of capacity is temporarily shut down. All shut-down capacity uses the older, high-pressure technology, whose economics have been eclipsed dramatically by the new, low-pressure processes.

Subject to market demand, some temporarily shut-down capacity might be converted to make linear low-density material. However, costs of conversion compared to costs of new plants or costs of conversion of high-density polyethylene plants make forecasts almost impossible on the outcome of the current capacity excess.

The likely result in 1983, unless an unusual demand surge comes along, is that more than 1 billion lb of capacity will remain idle. If production reaches 7.9 billion lb, remaining capacity will run at a very decent 87%. Counting all shut-down capacity, the plant-use rate for the year will drop to 78% from 81% in 1982. The recent high in plant use was 93% in 1979.

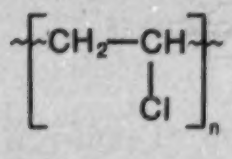
On the market side, U.S. uses of low-density polyethylene, counting all resin forms, will have roughly the same pattern as in recent years, with film dominating. Growth in film use will account for most of the production gain, excluding inventory building. This will favor linear low-density material, which goes largely into film. Further help here for linears will come from quality improvements.

Outside the U.S., low-density polyethylene faces a different picture. As with many other U.S. chemicals, exports will suffer because of the high value of the dollar and competition from new foreign plants with lower-cost feedstocks. After reaching almost 1.1 billion lb in 1982, close to the all-time high in 1980, exports of low-density polyethylene are forecast to drop 10% to about 1 billion lb in 1983.

The export sag will combine with competition for U.S. sales to take a toll on profitability and lead to more plant shutdowns. Efforts to raise polyethylene prices seem continuous but with little result. Enough new capacity will become available in 1983 that the pricing/profitability situation will remain much like 1982 despite a respectable volume increase. So this plastic will have a smart upturn in many respects but without much financial reward.

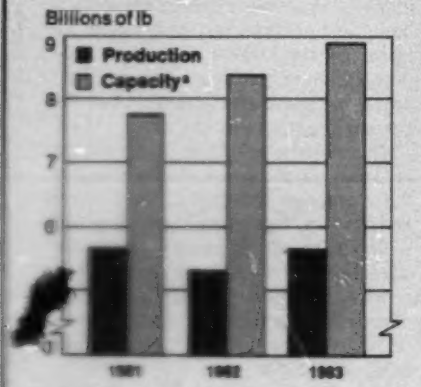
Key Polymers

Polyvinyl chloride



- ***Demand recovering***
- ***Capacity shaking out***
- ***Prices turning up***

PRODUCTION/CAPACITY



[a] First quarter

HOW MADE

Polymerization of vinyl chloride by suspension, emulsion, bulk, or solution processes initiated by free radicals

MAJOR FABRICATED FORMS (U.S.)

Extrusions, nearly two thirds pipe 65%; calendered sheet, film 10%

FOREIGN TRADE

Exports—declining to about 500 million lb in 1983, imports—staying about 50 million lb

PRICES

List prices unsettled, starting at 28 cents per lb; discounting large

COMMERCIAL VALUE

$1.5 billion for production, 1983

Signs of recovery finally are coming through for polyvinyl chloride, but it will take some time for this plastic to recover from the tumultuous times of the early 1980s. In 1983, even with a moderate production rebound powered by an improved construction market, polyvinyl chloride plants will bump along at only 64% of nameplate capacity.

The result will be a continued shakeout in this business, with more plants closing and more producers heading for the exit. In this respect, PVC is starting the new business cycle far different than in the late 1970s, when plant use strained the limit at 87% of capacity in 1979 and expansions rolled on and on.

PVC gets these wild cyclical changes in part because it is the thermoplastic most tied to the gyrating construction market, which takes a bit more than half of total U.S. PVC output. If home furnishings and other consumer items used around the house were included, construction's share of PVC demand would be still greater.

Unfortunately, at the beginning of a business recovery as at present, PVC lags construction because of the multistage pipeline extending back from construction sites to plastic extruders to resin producers. This "line-fill" time can account for as much as half a year, depending on perceptions of demand strength at different stages of the pipeline.

Currently, these perceptions indicate strong coming PVC demand in construction. Spurred by lower interest costs, these assessments call for renewed inventory building and increased PVC production, continuing a trend begun in late 1982. For 1983, output now is heading back to the 1981 level of 5.7 billion lb, possibly higher by 100 million to 200 million lb. This increase of 8% or higher still would leave PVC shy of its 1979 record of 6.1 billion lb.

As 1983 began, operable PVC plant capacity totaled 8.9 billion lb per year, but probably 1 billion lb of this was not running. How much shut-down capacity eventually will restart is difficult to estimate; not much will be tempted out under current financial conditions.

Later this year, startup decisions obviously will depend on PVC prices, including the differential between polymer and monomer prices. At this time efforts are under way to raise PVC prices. Part of the reason is that monomer prices are being pushed up under pressure from price hikes in raw material chlorine. With such cost pressure from the rear and with a moderate demand increase in front, PVC producers seem likely to get some price hike during 1983.

If, however, resulting price increases of a few cents per lb are not enough to cause shut-down PVC production units to restart, actual operating capacity of 8 billion lb will run at 71%. If production reaches 5.9 billion lb, the operating rate could rise to 74%. But, if all available capacity were included in the computation, operating rates would range from 64 to 66%.

At these levels of operation, PVC profitability is iffy. Price increases could help, along with greater volume, but the question remains: Is there enough money in PVC to justify development work to broaden uses of this versatile thermoplastic? Small producers probably cannot finance projects such as developing new compounds aimed at light and weather resistance—for example, in construction uses of siding and windows. These producers also can be at a cost disadvantage compared to larger producers integrated back to vinyl chloride and maybe chlorine. Hence, shut-down capacity at these smaller producers is more likely to remain closed this year and possibly never restart.

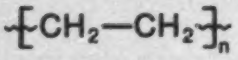
Besides the expected demand improvement in the construction market, some upturn will come in the many other uses, such as consumer products, electrical items, and packaging. However, none will outdistance construction in percentage growth.

The export market, which last year took about 10% of production, is expected to fall in 1983. One big reason is higher prices, up from bargain levels in 1982. Offsetting PVC exports for integrated producers may be an increase in exports of the polymer precursors, ethylene dichloride and vinyl chloride.

Without much help from exports, in 1983 PVC will ride largely on the fortunes of the U.S. construction business. Basics have impoved a lot here, but benefits for PVC will take a while, especially on the bottom line.

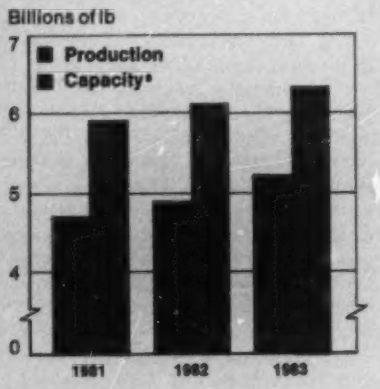
Key Polymers

High-density polyethylene



- ***Demand steadily up***
- ***Capacity rising***
- ***Prices still low***

PRODUCTION/CAPACITY



a First quarter.

HOW MADE

Polymerization of ethylene catalyzed by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Blow molding, mainly containers, 40%; injection molding 25%; pipe and conduit 10%; film and sheet 10%

FOREIGN TRADE

Exports—may fall below 600 million lb in 1983, imports—50 million lb

PRICES

List prices 45 cents per lb and up; discounts extensive

COMMERCIAL VALUE

$1.8 billion for production, 1983

Once again, high-density polyethylene provides some of the better news in the plastics world and retains its reputation as one of the best plastics businesses. In fact, it was the only one of the five major thermoplastics to increase production in 1982. And this year, it will be one of the few with sizable new investment.

Industry estimates put 1982 high-density polyethylene production at 4.9 billion lb, up 4% from 1981. For 1983, this steady growth will continue. Citing relatively large gains in production in late 1982, industry sources are even more optimistic for 1983, putting growth at 300 million to 500 million lb, or 6 to 10%, for a possible total of 5.4 billion lb.

In 1982, high-density polyethylene evaded the production drop in other thermoplastics largely on the strength of a more than 200-million-lb jump in exports. U.S. markets, notably the large container business for outlets such as gallon milk bottles, were about flat overall. For 1983, the growth pattern is due to switch, with a drop in exports and a gain at home.

As with other plastics, inventory forces are expected to influence production of high-density polyethylene in 1983. On one hand, producers with the capability of switching between high-density polyethylene and linear low-density polyethylene may raise inventories of high-density material temporarily and switch over, selling high-density from inventory for a while. This could put a slight damper on the year's overall production growth in high-density polyethylene. On the other hand, other producers adding capacity this year will need to build inventories to meet sales needs, thereby raising overall high-density polyethylene production.

Additional capacity coming on stream during 1983 will total more than 500 million lb per year. The dominant addition, about 450 million lb, is due to start up in the third quarter at Du Pont's plant near Bay City, Tex. Other capacity additions include American Hoechst's at Bayport, Tex., for ultrahigh-molecular-weight, high-density polyethylene, with capacity of 30 million lb a year. The unit is due on stream this month.

Excluding production from this new capacity, operable plants will have to run over 80% of capacity if 1983 production is to reach 5.2 billion lb. Including some production from new capacity, the operating rate still would remain close to 80%, the highest level for all major thermoplastics in 1983. High-density polyethylene certainly will top 80% if production surges to the levels proposed by its more optimistic analysts. For 1984, even with the added capacity in 1983, plant operations probably will do at least as well if the business recovery continues as expected.

Because some existing capacity can be shifted between high-density and linear low-density polyethylene, questions arise about operating rates required of other plants that cannot be switched. This high-density capacity might have to run higher than anticipated, according to some analysts, if demand for linear low-density polyethylene is strong. Of course, no resulting supply problems are in store for high-density polyethylene customers.

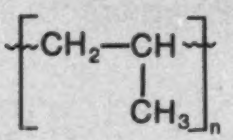
All these customers' major uses of high-density polyethylene now appear caught up in the business recovery. Use in injection molding, one quarter of the overall market, may be growing somewhat faster than other areas. A few very small uses also may exceed the average growth rate for the large blow-molding (container) market and other areas.

Exports are expected to slow down in 1983, in part as a result of the strong dollar and a lagging business recovery abroad. Exports climbed strongly in 1982 to a new high point, 14% of production. However, such performance isn't expected again.

The resulting damper on exports has the same effect on high-density polyethylene as does the moderate recovery at home—low profitability. List prices for most high-density grades haven't moved significantly in the past year, and neither have actual selling prices other than to reflect aberrations in raw material ethylene prices. The price calm hasn't done much for profits, and little improvement is expected for 1983 even with increased sales volume. In this respect, high-density polyethylene hasn't pulled out of thermoplastics' rut even though in many other ways it is one of the most attractive polymers.

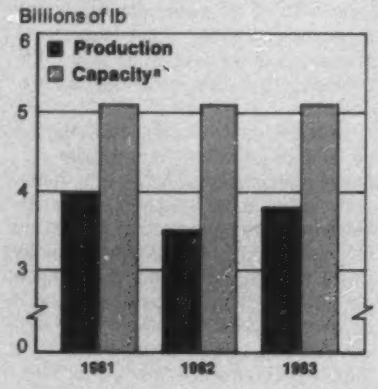
Key Polymers

Polypropylene



- ***Demand mending***
- ***Capacity flat***
- ***Prices discounted***

PRODUCTION/CAPACITY



[a] First quarter.

HOW MADE

Polymerization of propylene catalyzed by metallic salts and alkyls

MAJOR FABRICATED FORMS (U.S.)

Injection molding 40%, fibers 30%, film 10%

FOREIGN TRADE

Exports—declining to about 700 million lb in 1983, imports—about 10 million lb

PRICES

List prices 42 cents per lb and up; discounting large

COMMERCIAL VALUE

$1.3 billion for production, 1983

Polypropylene was shaken badly by the recession, which for the moment has undercut all the glowing forecasts of the late 1970s for this plastic. Production fell about an eighth in 1982 from the record in 1981 and will recover so slowly that another year will be needed to reach new highs. That's bad news for all the companies that have poured new-entry or expansion money into polypropylene since 1975. At the moment, the investment wave is over, but the resulting overbuilt capacity keeps prices at unprofitable levels.

A combination of slumps in two key markets for polypropylene—autos and housing—and abnormally high costs of feedstock propylene for much of 1982 dropped production to less than 3.5 billion lb, off 12% from 1981. Sales in 1982 dropped only half as much as production, suggesting that inventories were pulled down more than 200 million lb.

This inventory drop could set the stage for a relatively stronger recovery in 1983 for polypropylene than for the polyethylenes. Production could increase 8% this year to about 3.8 billion lb, still below the 1981 high of about 4 billion lb. Some industry sources, however, doubt such a gain will occur, noting that at year end 1982 polypropylene's pickup was slower than for the polyethylenes. These analysts fear that polypropylene will struggle through 1983 with just a 5% gain, giving production of 3.7 billion lb or less.

In any event, U.S. polypropylene plants will run no higher than 75% of nameplate capacity on average this year. If production sticks at the pessimistic level, the operating rate will just break 72%.

Such relatively low operating rates for a polyolefin are the direct result of the capacity bulge in the late 1970s. Investment incentive is now zero and capacity has been almost flat for three years. No expansions will come on stream during 1983 either, other than the usual small gains from catalyst improvements and other process efficiencies. These gains might total 50 million lb among several polypropylene producers.

Other than exports, the big outlets for polypropylene all fell hard in 1982. Use in fibers, for example, declined almost a sixth from 1981. Fibers felt the decline in housing and in furnishings such as carpet and curtains. This fibers market, some 30% of U.S. polypropylene demand, probably will trail the current upturn in housing because of the lag time in ordering. The second half of 1983 could bring higher fiber use after carpet demand sops up large carpet inventories rumored to be held by manufacturers and dealers.

In general, the injection molding uses of polypropylene, some 40% of total U.S. consumption, were hit hard by the recession. These markets involve autos, appliances, toys, housewares, and many others. Recovery for these items will be spotty in 1983. Autos, for example, have posted smaller sales gains for the first quarter than analysts forecast. Such gains, plus the trend toward smaller cars, will result in little growth for polypropylene in this complex area in 1983. Appliance demand is doing better, along with demand for other consumer products that contain molded polypropylene. These uses could rise 10 to 15% in 1983, but they still will not get back to 1981 levels after declines exceeding 20% in 1982.

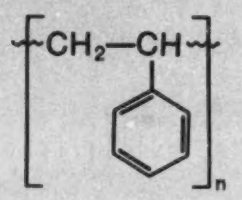
Exports were the brightest outlet for polypropylene in 1982, rising 8% to 740 million lb. However, the strength of the dollar and competition in world markets from producers in other countries are expected to pull exports below 700 million lb this year. The drop could be worse under the impact of declines in oil prices benefiting foreign producers.

Other major polypropylene markets in general are expected to aid the plastic's recovery. For example, high hopes exist in some quarters for polypropylene film, whose demand held up better in 1982. However, other opinion holds that film will have steady but not spectacular growth even though developmental work may overcome problems such as heat sealing.

Overall, polypropylene so far in the 1980s has failed producers' fond forecasts of the late 1970s. Even with a moderate upswing in demand this year, plant use and profitability will remain disappointing. Producers still have hopes for polypropylene and are pushing new-use development and downstream investment, but a big payoff is unlikely in 1983.

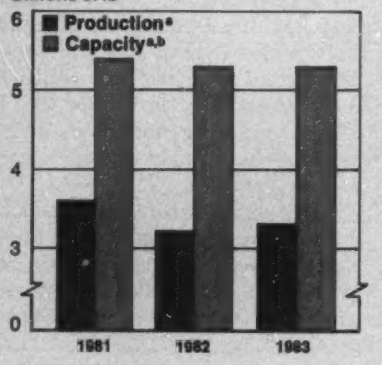
Key Polymers

Polystyrene



- ***Demand upturn small***
- ***Capacity flat***
- ***Prices very low***

PRODUCTION/CAPACITY



a All forms. b First quarter.

HOW MADE

Polymerization of styrene using a peroxide initiator

MAJOR FABRICATED FORMS (U.S.)

Injection molding 45%, extrusions 35%, expandable beads 15%; one third of end markets in packaging

FOREIGN TRADE

Exports—pushing to more than 100 million lb in 1983, imports—less than 10 million lb

PRICES

List prices 45 cents per lb and up; discounting large

COMMERCIAL VALUE

$1.2 billion for production, 1983

The polystyrene business is stirring this year, but that doesn't mean it's much better off. This is still the thermoplastic with the biggest headaches for producers—falling markets, low plant use, and no profit.

Production and sales of polystyrene will turn up in 1983, but less than for any of the other major thermoplastics. Instead, the main events for this polymer will be plant operating and ownership changes.

This producer shuffle and the possible permanent shutdown of some small plants reflect polystyrene's general malaise. Production in 1983 is expected to grow about 100 million lb, or just 3%, from 1982 to reach 3.3 billion lb. Packaging uses may lead the way.

This isn't much of a bounce, however, after a 1982 output level 11% below 1981 and 20% below the peak of 4.0 billion lb in 1979. The decline of the past three years and meager recovery expected in 1983 clearly show what polystyrene producers' problems come down to and why capacity is expected to decline. With the production slump, surplus capacity has put heavy pressure on selling prices, ruining profitability.

Polystyrene capacity definitely will shift. Some producers are adding to expandable bead capacity, but not all of this capacity will operate. At Mobil Chemical, polystyrene capacity is slated to increase 260 million lb per year in the second half of 1983 at Joliet, Ill. The expansion is in two units, one for 160 million lb per year of crystal polystyrene and the other for 100 million lb per year of high-impact polystyrene.

Overall, some polystyrene capacity now may be shut down for good, even though the owners have not yet indicated that these units will be scrapped, and so they are still included in capacity totals.

On paper then, given nameplate capacity of 5.3 billion lb per year, polystyrene will suffer an operating rate of just 62% in 1983 after 60% in 1982. These are the lowest rates among major thermoplastics.

If 5 to 10% of nameplate capacity is shut down at least temporarily, the operating rate for remaining capacity improves to 65 to 70%. But even at these rates, price pressure will keep profitability low and shutdown incentive high.

Not that polystyrene producers have given up trying to improve profitability. They have tried again and again to raise prices, only to be thwarted by one factor or another. For example, earlier this year, they rolled out a price increase of 2 cents a lb for most of the U.S. and 3 cents a lb for west of the Rockies. Asked what happened to the increase, one industry marketer simply says: "It's time to try again." At present, a higher spot price for raw material benzene might help lever a polystyrene price increase to reverse the squeeze in value between the two chemicals.

The root of polystyrene's financial problems is that it is a mature product largely on the defensive. It has only slow growth in old markets, where it dominates, and plenty of competition from other polymers in both these and newer markets. Seeing such limited growth prospects, some companies like Shell Chemical have gotten out of the business or are considering such a move. An upturn in polystyrene in 1983 and 1984 may put these exit plans on the shelf, but some analysts still expect permanent shutdowns of small plants.

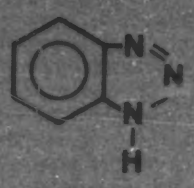
The 1981–82 recession hit polystyrene's uses across the board except for expandable beads, a product with some investment behind it. The recession hit polystyrene's major outlets in manufactured goods hard, and there was little polystyrene producers could do about it. Packaging, consumer goods such as toys, and electronic uses all fell badly. Innovations in these areas to increase polystyrene demand are limited and hard to justify for a product showing little or no return on investment.

Exports, an important aid to demand for other thermoplastics, are relatively small for polystyrene. Polystyrene exports dropped more than a third in 1982 to less than 100 million lb. They are forecast to recover somewhat in 1983 but probably not back to the 1981 level of 150 million lb. Longer-term prospects for exports are flat to slightly down.

Without much hope abroad, polystyrene is boxed into a declining U.S. market. It may not do much better than stabilize itself this year, and some plant owners' patience may run out.

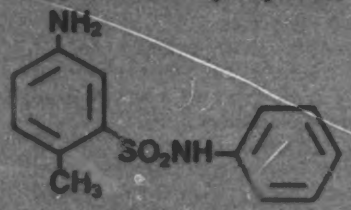
SANDOZ
Organic
Intermediates

Benzotriazole



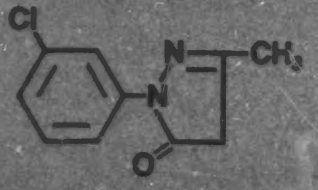
MW 119 CAS 95-14-7

1-Amino-4-methylbenzene-3-sulphonic acid-N-phenylamide



PTSL MW 262 CAS 79-72-1

1-(3'-Chlorophenyl)-3-methyl-5-pyrazolone



CPY MW 208.5 CAS 89-31-3

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CIRCLE 49 ON READER SERVICE CARD

Chemical firms rank high in information services

Years ago, recalls Eugene B. Jackson of the University of Texas, Austin, the vice president for R&D of a major metals-based firm told Jackson that he did not wish to determine, or even to know, the cost of information services in his corporation—"as it is below the nuisance level."

"Those days are gone forever, and the million-dollar-plus industrial information system is very much with us," Jackson observes. Moreover, he points out, chemical firms lead or rank high compared to other industrial groups in most categories related to information services that he has measured; the pharmaceutical industry also ranks high.

Thus, chemical firms lead in number of libraries, number of companies with international library systems, number of professional librarians, ratio of libraries to employees, and library penetration (a measure of company spending on information services). And these results exclude chemical libraries at pharmaceutical, petroleum refining, food, rubber, and other chemical-related firms. Jackson, a professor at Texas University's graduate school of library and information science, outlined his estimates of chemical industry spending on technical information services at the Symposium on the Cost of Providing Information from an Industrial Information Center, held by the Division of Chemical Information at the American Chemical Society national meeting in Seattle.

Jackson calculates that 120 libraries and technical information centers run by chemical firms in the *Fortune* 500 spend well over $50 million a year. It appears, he notes, that the chemical industry spends about 2% of its R&D budget for technical information services.

Of the $50.7 million spending that he can assign to specific budget categories, the biggest portions go to personnel costs ($18.2 million, 36%) and materials ($17.3 million, 34%). As

Top four companies spend almost half of chemical industry outlays for information services

Extended budget, $ thousands[a]	Top four firms	Other firms	All firms
Personnel	$ 9,164	$ 9,037	$18,201
Managerial, professional[b]	4,620	4,883	9,503
Nonprofessionals[b]	3,734	3,201	6,935
Travel	270	313	583
Continuing education	540	640	1,180
Materials	8,813	8,457	17,270
Books, monographs[c]	3,756	3,339	7,096
Periodicals, serials[c]	3,532	3,464	6,997
Government documents, maps, patents	939	835	1,774
Photocopies	420	588	1,008
Document delivery products	165	231	396
Services	4,916	6,348	11,264
On-line bibliographic and numeric reference services	2,610	3,150	5,760
On-line technical processing	300	420	720
Binding of periodicals	100	140	240
Computer system support	1,250	1,750	3,000
Telephone and telecommunications	92	99	191
Records management	564	789	1,353
Facilities[d]	1,564	2,262	3,826
Supplies: technical processing	50	70	120
TOTAL	**$24,507**	**$26,174**	**$50,681**

a Data include estimated budgets for libraries and technical information centers for top four chemical firms in all categories, and for 25 other chemical firms from the "*Fortune* 500" for most categories (three categories include data from only 20, 21, or 22 "other firms"). b Including fringe benefits. c Including permanent retention. d Including utilities, janitorial services, and minor repairs. **Note:** Data do not include budget categories that could not be estimated; for example, temporary assistance, external and internal research reports, on-line "high ticket" marketing information services, publications and dissemination services, word processing services, competitor analysis services, and records management off-site. **Source:** Eugene B. Jackson, University of Texas, Austin

CHECKOFF

NEW PLANTS

■ **Carbon fibers.** Great Lakes Carbon will build plant in Roane County in Tennessee to produce 800,000 lb per year of these fibers, with design to add capacity as use warrants. Completion due in 1984.

■ **Fungicide.** Uniroyal Chemical will build unit in Naugatuck, Conn., to make Vitavax, its proprietary systemic fungicide used on seeds of small grains. Timetable for construction and capacity of plant was not disclosed.

■ **Industrial gases.** Airco Industrial Gases has begun construction on 465-ton-per-day air separation plant in Aiken, S.C., which will cost more than $15 million and be completed in summer of 1984.

■ ***p*-Xylene.** Chevron Chemical plans to expand capacity of unit at Pascagoula, Miss., to 500 million lb per year from present 430 million lb of this raw material for polyesters. Cost is not disclosed for project, to be completed by end of 1984.

■ **Specialty inorganics.** Calabrian Chemicals will build units to make sodium thiosulfate and sulfamic acid at its plant in Port Neches, Tex., with completion due in second-quarter 1983; capacities and cost were not disclosed.

■ **Thioglycolic acid.** M&T Chemicals, wholly owned subsidiary of Elf Aquitaine of France, will build plant at company's Mobile, Ala., site to make 4000 metric tons per year of this intermediate used in producing stabilizers for polyvinyl chloride and in cosmetic ingredients. Completion of multimillion dollar unit is slated for fourth quarter of 1984.

PLANTS COMPLETED

■ **Ethylene.** Arco Chemical has started up first of two cracking furnaces designed by M. W. Kellogg that increase output and efficiency. When second furnace is on stream, Arco Chemical's ethylene capacity at Channelview, Tex., plant will be 2.4 billion lb per year.

■ **Sulfuric acid.** Conserv, the phosphate fertilizer subsidiary of Phibro-Salomon, dedicated its new sulfuric acid plant at Nicholas, Fla., last month. Plant can produce 730,000 tons per year of acid and cogenerates 13 MW of electricity.

might be expected, the largest single category is managerial and professional salaries and fringe benefits ($9.5 million), followed by the costs of books and monographs ($7.1 million), periodicals and serials ($7.0 million), nonprofessional salaries and fringe benefits ($6.9 million), and on-line bibliographic and numeric reference services ($5.8 million). The four largest chemical firms in the U.S.—Du Pont, Union Carbide, Monsanto, and Dow Chemical—together spend almost as much on their 50 information centers as all the others do on their 70 centers.

Jackson notes that his estimates are considerably larger than would be derived from just "conventional budget" items. He calculates instead an "extended budget," including real costs of supplying technical information services that are rarely or never included in conventional budgets, such as staff fringe benefits, costs for permanent retention of books and periodicals, and computer system support.

Indeed, he points out, his estimates are still too low because he could not estimate costs for a number of important budget categories such as temporary assistance, external and internal research reports, and on-line "high ticket" marketing information services. Moreover, the data available did not enable him to make estimates for all categories for several firms, and a few firms had to be excluded completely. In addition, chemical firms not in the *Fortune* 500 were not included.

Jackson points out that chemical industry budgets for information services are generally considered proprietary and are not revealed. His deductions are made by combining data, inferences, and extrapolations from open sources, such as standard directories of information centers and their staffs, professional society salary surveys, indexes of literature materials and services costs, and reports of corporate R&D spending. Instead of such extrapolations, he urges adoption of a mechanism for systematically and confidentially compiling data from chemical firms. However, Jackson's approaches to the Chemical Manufacturers Association and others about setting up a clearinghouse have so far not borne fruit. □

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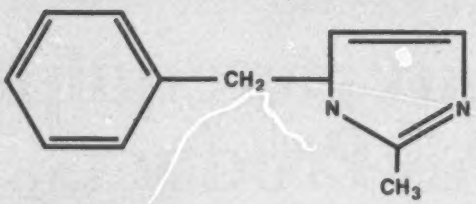

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CIRCLE 42 ON READER SERVICE CARD

Industry Project Aims at Cutting Federal Government Costs

Survey is examining all government operations; most recommendations call for management-level changes, some paring of R&D budgets

One of President Reagan's goals is to improve the efficiency of the federal bureaucracy. And a major effort to get a handle on this problem is the Private Sector Survey on Cost Control. Set up in June 1982, this large project is headed by W. R. Grace chairman J. Peter Grace and is being staffed and funded entirely by private industry.

Grace assembled 163 executive committee members for the survey from the nation's leading corporations, who in turn recruited 1300 task force volunteers. These workers aim to produce 38 reports on all segments of the federal government, looking at ways to cut costs by changing management practices and improving efficiency. The entire project is expected to cost about $50 million, all of which will be paid for by private contributions.

Grace says this project differs from others bent on finding ways to improve the federal government. "From the beginning, the concept of the survey was unique in its approach," he says. "Our effort was more massive and involved a tremendous amount of expertise. . . . I don't think anything like it has been done before."

The first six reports already have been released. Most of the departments studied have research and development budgets. The reports are on the departments of Commerce, Agriculture, Health & Human Services, and Energy (combined with the Nuclear Regulatory Commission), and the Environmental Protection Agency (combined with the Small Business Administration and the Federal Emergency Management Agency). Recommendations concern all levels of agency activities, but most of them deal with management-level changes. Still, the R&D areas are not immune to some paring.

C&EN staff photo

Grace: survey is unique in approach

Some of the more major changes are recommended for DOE research. Dollar savings are not listed for some of the changes, but if implemented they would change how the department does research. Primarily, the Cost Control Survey recommends that more independence be given to the directors of the national laboratories. A multiyear rolling budget for research would give them that autonomy, but, the survey argues, that leads to another problem. The labs lack direction. The survey finds a serious need for an authoritative and specific outline on an overall R&D mission for the national labs, something that apparently has not been done. This would eliminate the duplication of efforts found at some labs and help eliminate "some unseemly competition for funds among the R&D operations" at DOE.

Other recommendations include a critical look at DOE funding of the Clinch River breeder reactor and of the full-blown gas centrifuge enrichment plant. Support of these projects is in conflict with established DOE policy of not funding existing technologies that are ready for commercialization, the report says, noting that several billion dollars could be saved if they were dropped.

In another item, the survey shows that the government could save about $1.25 billion by relieving itself of management of the Strategic Petroleum Reserve and making it a government-owned, contractor-operated facility.

DOE's military projects also were scrutinized. One recommended change is that the U.S. "take the technologically feasible but psychologically troublesome step" of using civilian nuclear power reactors as a source of radionuclides to replace those that decay in nuclear warheads over time.

Major changes also are recommended for EPA. For R&D, it recommends that eight of the agency's 14 regional labs be closed. These are small facilities, usually with fewer than 20 employees, that the survey argues are not adequate to handle the increasing demand for analysis of trace substances in toxic waste site samples. The survey also finds that EPA could get more research out of its depleted R&D budget if it would increase the number of cooperative agreements between its labs and if a long-term plan for research were developed.

Much of the EPA savings would come from completing the transfer of duties to state agencies. The biggest saving, about $15 million, would come from complete transfer of the National Pollution Discharge Elimination System permit program to the states. Several states do not have EPA-approved programs, and unless they get them soon, the survey recommends EPA drop grants from this program to those states. Presently, in addition to EPA's approving the permits, the states use the grants for their own, duplicate process, creating a dual permitting system, both financed by the federal government.

Commerce's National Bureau of Standards came in for some careful examination. The survey found that 20 to 30% of the programs being done at NBS are not part of the agency's original mission and could be taken over by private companies. These include projects mostly in the areas of chemical engineering, manufacturing engineering, fire research, building technology, analytical chemistry, and materials science.

The research recommendations for HHS and USDA are somewhat related. The survey makes no suggestions to cut support for the National Institutes of Health or for most agriculture research. But it finds that the nutrition centers supported by the Agriculture Research Service could be eliminated, as they appear to duplicate the much larger and better funded nutrition programs at NIH. There also are about 20 programs of the Cooperative State Research Program that could be eliminated and/or taken over by the private sector. Most of those are marketing programs, tracking foreign agriculture developments, or consumer-oriented information programs.

All the changes recommended for research are overwhelmed by the changes sought in personnel practices for federal workers. Changes in the civil service retirement system could save more than $15 billion in the first year, the survey calculates. Other changes in federal health benefits, annual leave, sick leave, and pay comparability that would bring the federal government more in line with practices of the largest private companies would save up to $35 billion in just three years.

Trimming federal employee benefits gives greatest savings

$ Millions	1st Year	2nd Year	3rd Year	Total
Agriculture Department	$ 2,458.5	$ 2,883.5	$ 3,217.5	$ 8,559.0
Commerce Department	33.0	52.5	60.3	145.8
Energy Department/Nuclear Regulatory Commission	548.0	826.9	903.6	2,278.5
Environmental Protection Agency/ Small Business Administration/ Federal Emergency Management Administration	357.4	541.9	610.8	1,510.1
Health & Human Services Department	129.9	173.4	190.9	494.2
Personnel benefits	10,219.9	11,533.8	12,972.1	34,725.8
TOTAL	$13,746.7	$16,012.0	$17,954.7	$47,713.4

Note: These savings represent only those amounts for which the survey believes it can fully support the recommended changes. Source: President's Private Sector Survey on Cost Control

Public meetings on these and the other cost-control survey reports will be held over the next couple of months. All the reports are expected to be completed and sent to the President this summer. The biggest question is how many of the thousands of recommended changes will be tried.

Grace says that for some agencies, as many as 90% of the recommendations can be carried out by the agency heads on their own. In all, about 40% of the suggestions would require Congressional action to implement them.

Reagan had a similar survey done when he was governor of California and tried to put about 70% of the suggested changes into practice there. Grace is confident most of this cost-control survey will be tried as well, but seasoned observers say they have seen other well-meaning efforts to control the government come to very little. □

1984 budget favors research at universities

The outlook in the Administration's proposed budget for fiscal 1984 is quite favorable for basic research in chemistry—in particular, research conducted at academic institutions. In contrast, the chemistry work that is incidental to missions of federal agencies would not fare as well.

These are the conclusions presented in the American Association for the Advancement of Science's preliminary analysis of R&D in the fiscal 1984 budget. The chapter on chemistry was prepared by Le-Nhung McLeland and Annette T. Rosenblum of the American Chemical Society's Department of Public Affairs, who ferreted out details on chemistry funding not readily available in the Administration's formal budget proposals (C&EN, Feb. 7, page 9).

For the Department of Defense, the report says, it is assumed that funding for basic research in chemistry and materials will increase 12.7%, the same as the overall increase for basic research, but it is possible that chemistry and materials will receive a larger share of the increase, as was the case last year. The report notes that two areas of DOD emphasis that involve considerable work in chemistry are development of advanced composite materials and chemical defense, where plans are afoot to develop vaccines and therapeutics for chemical/biological defense. DOD reports that the university contract base in the chemical defense program has doubled recently.

At the Department of Energy, the report notes, proposed funding for the geosciences program includes an increase of about $400,000 for geochemistry research—geomigration and organic geochemistry. However, the proposed budget for environmental R&D is expected to force reductions in all ongoing programs, including research on dry (acid) deposition and measurement of toxic agents generated by energy opera-

Chapel Hill, Berkeley head graduate rankings

The University of North Carolina, Chapel Hill, remains the nation's largest producer of bachelor's degree chemistry graduates. And the University of California, Berkeley, has displaced the University of Illinois, Urbana-Champaign, as the biggest producer of Ph.D. chemistry graduates for the second time in the past nine years.

These are two of the findings from C&EN's analysis of the mass of data contained in the latest annual report of ACS's Committee on Professional Training. This committee is the mechanism through which ACS sets standards for and monitors undergraduate chemistry education. The committee also gathers data from the more than 500 schools with undergraduate programs it has approved on chemistry graduations at all levels. (The text of the committee's latest report covering the 1981–82 academic year starts on page 70.)

Chapel Hill has been the largest producer of bachelor's degree chemists for eight of the past nine academic years. It was dislodged by Indiana University in 1979–80 but regained the lead the following year, pushing Indiana down to second. Indiana retains the second spot in the latest report.

The top spot among the producers of Ph.D. chemists has alternated between Berkeley and Urbana-Champaign for the past four years. In the latest report, Urbana-Champaign has to settle for second place.

For the first time in eight years, the University of California, San Diego, is not the largest producer of certified bachelors graduates. Instead, it slips to second place, behind Rutgers University. Such graduates have completed a curriculum certified by CPT and are immediately eligible for membership in ACS.

A total of 66 schools appear on at least one of the four listings in this article. These listings rank the 25 largest producers of bachelors graduates, certified bachelors graduates, M.S. graduates, and Ph.D. graduates. Only three schools—San Diego, Urbana-Champaign, and UCLA—appear on all four lists. □

These schools had the most chemistry graduates, 1981–82

Total bachelors graduates

1.	U of North Carolina, Chapel Hill	136
2.	Indiana U	134
3.	U of Illinois, Urbana-Champaign	131
4.	U of Maryland	106
5.	U of Pittsburgh	104
6.	U of California, Los Angeles	99
7.	Rutgers U, New Brunswick	85
8.	U of Virginia	83
9.	Emory U	82
10.	Duke U	77
11.	U of South Florida	76
12.	Miami U	72
13.	U of California, San Diego	70
14.	U of Miami	68
15.	U of Washington	65
16.	State U of New York, Stony Brook	64
17.	California Polytechnic State U	62
17.	U of Florida	62
19.	St. Louis U	59
20.	U of California, Berkeley	58
21.	U of Colorado, Boulder	56
22.	West Virginia U	51
23.	Creighton U	50
23.	U of Texas, Austin	50
25.	St. Olaf C	49

Certified bachelors graduates

1.	Rutgers U, New Brunswick	73
2.	U of California, San Diego	70
3.	U of Pittsburgh	60
4.	U of Illinois, Urbana-Champaign	54
5.	U of Texas, Austin	50
6.	U of California, Berkeley	46
6.	U of Washington	46
8.	U of Michigan, Ann Arbor	44
9.	Massachusetts Inst. of Tech	38
10.	Indiana U	37
10.	U of North Carolina, Chapel Hill	37
12.	C of William and Mary	36
13.	State U of New York, Stony Brook	33
13.	Rensselaer Polytechnic Inst.	33
15.	U of Cincinnati	32
15.	Illinois State U	32
17.	U of California, Los Angeles	31
18.	U.S. Naval Academy	30
19.	U of Delaware	29
20.	Stanford U	28
21.	U of Minnesota, Minneapolis	26
21.	Ohio State U	26
23.	Georgia Institute of Technology	25
24.	C of the Holy Cross	24
24.	Lehigh U	24

Masters graduates

1.	Cornell U	31
2.	U of Michigan, Ann Arbor	29
3.	Ohio State U	28
4.	Northwestern U	25
5.	Yale U	24
6.	U of Illinois, Urbana-Champaign	23
7.	Purdue U	22
8.	Harvard U	21
9.	U of California, San Diego	20
9.	Columbia U	20
11.	U of Cincinnati	19
11.	San Diego State U	19
13.	Lawrence U	18
13.	U of Rochester	18
15.	Rensselaer Polytechnic Inst.	17
16.	San Jose State U	16
17.	U of Illinois, Chicago	15
17.	Wright State U	15
19.	U of California, Los Angeles	14
19.	Illinois Institute of Technology	14
19.	Michigan State U	14
22.	U of California, Santa Barbara	13
22.	Lehigh U	13
22.	U of Missouri, St. Louis	13
22.	North Carolina State U	13
22.	Seton Hall U	13
22.	Stevens Institute of Technology	13
22.	U of Washington	13
22.	U of Wisconsin, Madison	13

Doctoral graduates

1.	U of California, Berkeley	66
2.	U of Illinois, Urbana-Champaign	60
3.	U of Wisconsin, Madison	50
4.	Massachusetts Inst. of Tech	36
4.	Michigan State U	36
6.	Purdue U	33
7.	U of California, Los Angeles	30
7.	Cornell U	30
9.	U of California, San Diego	29
9.	U of Texas, Austin	29
11.	Northwestern U	28
11.	Ohio State U	28
13.	Columbia U	27
14.	Harvard U	26
14.	U of North Carolina, Chapel Hill	26
16.	California Institute of Tech	25
16.	Pennsylvania State U	25
16.	U of Pennsylvania	25
19.	Indiana U	24
20.	Iowa State U	22
20.	U of Maryland	22
22.	U of Chicago	21
22.	Princeton U	21
24.	Stanford U	20
25.	U of Iowa	19
25.	U of Minnesota, Minneapolis	19

ACS Committee on Professional Training 1982 Annual Report

The number of bachelor's degree graduates in chemistry from colleges and universities whose undergraduate chemistry programs are approved by the American Chemical Society decreased 5.6% in the 1981–82 academic year from the previous year. The number of master's degrees from these departments rose 2.2%, and the number of Ph.D. degrees continued to rise for the third year in a row, this year 4.4%.

The percentage of baccalaureate graduates certified by ACS rose slightly from 41% to 42%. (Certified graduates are those who have completed the curriculum specified by the Committee on Professional Training and are eligible for full membership in ACS; noncertified graduates may become associate members of ACS upon graduation and full members after three years of professional experience or a higher degree in a chemical science.)

A total of 2252 of the bachelor's degree graduates from the approved schools were reported as planning to go to graduate school and 1990 reported plans to go to professional schools.

Total numbers of bachelor's degrees (certified and noncertified), master's degrees, and Ph.D. degrees awarded in 1981–82 by departments whose chemistry programs are ACS approved are listed by institution in the large table at the end of this report and are summarized in the two smaller tables. These tables also include numbers of chemical engineering graduates from institutions whose programs are accredited by the American Institute of Chemical Engineers and the Accreditation Board for Engineering & Technology. (Note: Those departments are not required to report their data to CPT, so the number of departments included varies each year.) A new table with this year's report includes information on graduate student enrollments in chemistry departments whose undergraduate programs are ACS approved.

The number of bachelor's degrees in chemical engineering from the 113 AIChE-ABET-accredited departments that reported in 1982 increased 2.3% from the total reported by 110 departments in 1981. These 113 departments reported an expected further increase of 12% in 1983.

During the five-year period from 1978 to 1982, the number of reported bachelor's degree graduates in chemical engineering increased 41%. At the graduate level, the number of

Summary of data from approved programs, 1978–82

	Bachelors				Masters		Doctorates	
	Number of schools	Graduates (totals)	Certified graduates	Non-certified graduates	Number of schools	Graduates	Number of schools	Graduates
CHEMISTRY								
1978	547	10,350	4285	6065	323	1798	189	1532
1979	551	10,451	4424	6027	323	1716	188	1532
1980	554	10,170	4170	6000	324	1698	188	1561
1981	558	10,453	4337	6116	323	1609	187	1613
1982	561	9,866	4179	5687	322	1645	187	1683
CHEMICAL ENGINEERING[a]								
1978	119	4,225	4225	—	114	1109	98	251
1979	112	4,977	4977	—	107	951	92	237
1980	109	5,348	5348	—	105	974	88	243
1981	110	5,831	5831	—	106	1020	87	250
1982	113	5,963	5963	—	109	1171	92	293

a Chemical engineering departments are not required to report their data to CPT, so the number of departments included in this category varies from year to year. NOTE: Bachelor's degree projections for 1983: 561 chemistry departments report that they expect a total of 10,585 bachelor's degree graduates with majors in chemistry during the 1982–83 academic year, and 113 chemical engineering departments report that they expect a total of 6864 bachelor's degree graduates with majors in chemical engineering.

Summary of totals from 1982 reports from approved programs

	Schools reporting	Men	Women	Total
CHEMISTRY				
Bachelors, total	561	6861	3005	9866
Certified		2895	1284	4179
Noncertified		3966	1721	5687
Masters	322	1154	491	1645
Doctorates	187	1411	272	1683
CHEMICAL ENGINEERING				
Bachelors, certified	113	4636	1327	5963
Masters	109	1000	171	1171
Doctorates	92	279	14	293

Committee members, 1982

J. Arthur Campbell, *chairman*
Harvey Mudd College

Henry A. Bent, *acting chairman, January to June*
North Carolina State University

Alice J. Cunningham
Agnes Scott College

Ernest L. Eliel
University of North Carolina, Chapel Hill

Patricia A. M. Figueras
Eastman Kodak Research Labs

Harry B. Gray
California Institute of Technology

C. David Gutsche
Washington College

Donald E. Jones
Western Maryland College

Peter Lykos
Illinois Institute of Technology

Eli M. Pearce
Polytechnic Institute of New York

Melvin B. Robin
Bell Telephone Laboratories

Jere P. Segrest
University of Alabama, Birmingham

Bonnie R. Blaser, *secretary*

Mairin B. Brennan, *staff associate*
American Chemical Society

chemical engineering master's degrees reported in 1982 rose 15% from the year before, and the number of Ph.D. degrees reported increased 17%.

Programs at ACS-approved departments normally are re-evaluated at five-year intervals. There were 564 colleges and universities on the approved list at the end of 1982. The committee studied the chemistry programs at 153 of them during the year.

Each re-evaluation involved a review of extensive documentary materials submitted by the department head describing the current status of the program. During 1982, five chemistry programs were newly approved by the committee and two approved programs were put on probation. No departments were removed from the approved list in 1982.

During the year the committee continued its work in revising the criteria used to evaluate undergraduate programs in chemistry. Draft copies of the revision were sent to all of the ACS-approved schools, ACS divisions, and the CPT Visiting Associates, and open meetings to discuss the revision were held at both national meetings of the society last year.

Reports were prepared and disseminated on the committee's surveys on the use of computers in undergraduate chemistry programs and on the language requirements in graduate programs in chemistry. The committee conducted a second survey on the use of computers in undergraduate programs in the fall of 1982 and expects to prepare a report on this survey in 1983.

To determine why chemistry faculty members leave for other positions, especially nonacademic ones, the committee conducted a survey in 1980 on faculty mobility in the past 10 years (1970–79) in ACS-approved departments. To identify trends, followup surveys were conducted for the 1980 calendar year and again for 1981. The committee plans to continue these surveys and to prepare reports on faculty mobility in chemistry departments as trends are identified.

The committee agreed to include polymer and clinical chemistry programs in the 1983 edition of the ACS Directory of Graduate Research, a biennial publication that provides guidance information for students who are considering graduate education in chemistry and related fields. Currently the directory includes M.S.- and Ph.D.-degree granting departments of chemistry, chemical engineering, biochemistry, and pharmaceutical/medicinal chemistry in the U.S. and Canada. Included in each department's listing is biographical information on faculty members, their research interests, and titles of their publications for a two-year period.

Work continued on the development of the Directory of Graduate Research Concordance, a proposed computerized database of the names and research interests of faculty members included in the directory. It is planned that the database will be arranged in a hierarchical way so that it can be searched to yield information on faculty members who have expressed interest in any broad subject, or, on a reduced scope, to identify those with interests in exceedingly narrow disciplines. Because the database will be built on faculty lists in the 1983 directory, it will serve as a multilevel concordance for this volume.

Fall 1981 grad student enrollments in departments whose undergraduate chemistry programs are ACS approved

	Number of departments	First-year graduate students		All graduate students	
		Full time	Part time	Full time	Part time
M.S. departments[a]	135	448	366	1,073	1044
Ph.D. departments	187	3248	311	12,835	1518
TOTAL	322	3696	677	13,908	2562

a Departments whose highest offering is the master's degree in chemistry.

Chemistry and chemical engineering degrees awarded by approved schools, 1981–82

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Abilene Christian U	4	2	0	—	—	—	—
Adelphi U	4	7	0	—	—	—	—
Agnes Scott C	3	0	—	—	—	—	—
Akron, U of	16	4	4	4	30	6	2
Alabama, U of							
University	2	12	3	4	28	3	2
Birmingham	9	10	6	1	—	—	—
Huntsville	3	6	3	—	—	—	—
Alaska, U of	1	0	2	—	—	—	—
Albion C	5	24	—	—	—	—	—
Albright C	6	11	—	—	—	—	—
Alfred U	7	0	—	—	—	—	—
Allegheny C	0	36	—	—	—	—	—
Alma C	2	5	—	—	—	—	—
American U	4	0	6	5	—	—	—
Amherst C	3	6	—	—	—	—	—
Andrews U	7	9	—	—	—	—	—
Appalachian State U	1	8	0	—	—	—	—
Arizona State U	16	8	2	14	36	9	0
Arizona, U of	14	18	6	15	29	9	3
Arkansas, U of							
Fayetteville	3	16	3	11	42	4	1
Little Rock	5	6	2	—	—	—	—
Ashland C	2	3	—	—	—	—	—
Auburn U	4	28	5	5	74	7	0
Augsburg C	0	8	—	—	—	—	—
Augustana C (Illinois)	0	9	—	—	—	—	—
Augustana C (South Dakota)	0	6	—	—	—	—	—
Austin C	3	8	—	—	—	—	—
Baldwin-Wallace C	0	6	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No.	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Ball State U	7	1	6	—	—	—	—
Barnard C	3	8	—	—	—	—	—
Bates C	4	11	—	—	—	—	—
Baylor U	20	19	0	2	—	—	—
Beloit C	1	12	—	—	—	—	—
Bemidji State U	4	4	—	—	—	—	—
Birmingham-Southern C	3	14	—	—	—	—	—
Bloomsburg State C	1	5	—	—	—	—	—
Boston C	11	27	5	2	—	—	—
Boston U	1	16	5	3	—	—	—
Bowdoin C	2	34	—	—	—	—	—
Bowling Green State U	3	22	9	—	—	—	—
Bradley U	1	11	—	—	—	—	—
Brandeis U	0	8	9	9	—	—	—
Bridgeport, U of	4	1	7	—	—	—	—
Bridgewater State C	3	8	0	—	—	—	—
Brigham Young U	19	23	2	5	39	6	0
Brown U	1	26	5	10	—	—	—
Bryn Mawr C	14	0	0	0	—	—	—
Bucknell U	9	15	4	—	36	1	—
Butler U	5	8	2	—	—	—	—
California Institute of Tech	5	5	3	25	15	10	9
California Polytechnic State U	22	40	2	—	—	—	—
California State C							
Bakersfield	5	1	—	—	—	—	—
San Bernardino	2	3	—	—	—	—	—
Stanislaus	3	2	—	—	—	—	—
California State Polytechnic U	11	10	3	—	a		
California State U							
Chico	2	12	—	—	—	—	—
Dominguez Hills	11	4	—	—	—	—	—
Fresno	7	2	3	—	—	—	—
Fullerton	17	16	4	—	—	—	—
Hayward	12	19	1	—	—	—	—
Long Beach	13	25	8	—	a		
Los Angeles	10	1	5	—	—	—	—
Northridge	12	9	2	—	—	—	—
Sacramento	11	9	4	—	—	—	—
California, U of							
Berkeley	46	12	11	66	133	27	13
Davis	19	3	5	7	40	13	2
Irvine	13	31	4	10	—	—	—
Los Angeles	31	68	14	30	—	—	—
Riverside	14	0	6	9	—	—	—
San Diego	70	0	20	29	—	—	—
Santa Barbara	12	7	13	9	47	6	3
Santa Cruz	20	5	0	1	—	—	—
Calvin C	3	5	—	—	—	—	—
Canisius C	3	4	—	—	—	—	—
Capital U	0	9	—	—	—	—	—
Carleton C	11	12	—	—	—	—	—
Carnegie-Mellon U	19	2	6	3	83	21	10
Carroll C	1	3	—	—	—	—	—
Carthage C	2	5	—	—	—	—	—
Case Western Reserve U	11	21	9	6	49	8	1
Catholic U of America	5	2	3	1	4	2	0
Centenary C of Louisiana	0	3	—	—	—	—	—
Central C	1	4	—	—	—	—	—
Central Connecticut State C	8	0	3	—	—	—	—
Central Florida, U of	22	0	3	—	—	—	—
Central Michigan U	1	15	3	—	—	—	—
Central State U							
Wilberforce, Ohio	4	4	—	—	—	—	—
Edmond, Okla.	0	10	—	—	—	—	—
Charleston, C of	10	2	—	—	—	—	—
Chatham C	1	1	—	—	—	—	—
Chestnut Hill C	0	7	—	—	—	—	—
Chicago, U of	4	30	4	21	—	—	—
Cincinnati, U of	32	0	19	16	70	13	0
Citadel, The	2	9	—	—	—	—	—
City U of New York							
Graduate Center	—	—	—	7	—	—	—
Brooklyn C	1	34	1		—	—	—
City C	0	14	3		27	4	2
Herbert H. Lehman C	1	4	—		—	—	—
Hunter C	3	16	0		—	—	—
Queens C	7	21	3		—	—	—
Clarion State C	3	2	—	—	—	—	—
Clark U	17	0	0	3	—	—	—
Clarkson C of Tech	28	0	1	5	130	5	2
Clemson U	7	3	4	3	56	8	1
Cleveland State U	17	0	11	1	61	7	0
Coe C	1	5	—	—	—	—	—
Colby C	4	11	—	—	—	—	—
Colgate U	1	20	—	—	—	—	—
Colorado C	9	4	—	—	—	—	—
Colorado School of Mines	3	0	10	2	75	11	2
Colorado State U	22	14	2	11	24	7	—
Colorado, U of							
Boulder	12	44	6	17	67	10	2
Denver	2	6	0	—	—	—	—
Columbia U	9	32	20	27	42	31	6
Concordia C	4	12	—	—	—	—	—
Connecticut, U of	16	15	5	3	49	9	0
Cooper Union[b]	—	—	—	—	29	6	—
Cornell C	0	12	—	—	—	—	—
Cornell U	23	20	31	30	72	20	4
Creighton U	4	46	2	—	—	—	—
Dartmouth C	0	25	1	4	—	—	—
David Lipscomb C	2	17	—	—	—	—	—
Davidson C	9	1	—	—	—	—	—
Dayton, U of	5	7	3	—	50	2	—
Delaware State C	0	3	—	—	—	—	—
Delaware, U of	29	15	10	9	57	19	11
Delaware Valley C of Science & Agriculture	5	0	—	—	—	—	—
Delta State U	3	9	2	—	—	—	—
Denison U	2	4	—	—	—	—	—
Denver, U of	8	12	4	2	—	—	—
De Paul U	1	0	5	—	—	—	—
DePauw U	4	9	—	—	—	—	—
Detroit, U of	7	2	6	2	14	10	5
Dickinson C	7	12	—	—	—	—	—
Drake U	2	7	—	—	—	—	—
Drew U	1	14	—	—	—	—	—
Drexel U	16	0	11	5	79	6	1
Duke U	15	62	6	11	—	—	—
Duquesne U	4	10	3	1	—	—	—
Earlham C	0	4	—	—	—	—	—
East Carolina U	6	10	3	—	—	—	—
East Stroudsburg State C	4	11	1	—	—	—	—
East Tennessee State U	5	5	4	—	—	—	—
East Texas State U	2	1	3	—	—	—	—
Eastern Illinois U	6	4	4	—	—	—	—
Eastern Kentucky U	5	10	2	—	—	—	—
Eastern Michigan U	1	28	2	—	—	—	—
Elizabethtown C	0	15	—	—	—	—	—
Elmhurst C	1	7	—	—	—	—	—
Emory U	9	73	9	14	—	—	—
Emporia State U	0	3	3	—	—	—	—
Evansville, U of	3	4	—	—	—	—	—
Fairfield U	9	7	—	—	—	—	—
Fairleigh Dickinson U							
Florham-Madison[c]					—	—	—
Rutherford	3	0	3	—	—	—	—
Teaneck	3	0	2	—	—	—	—
Fisk U	10	0	2	—	—	—	—
Florida Atlantic U	4	19	1	0	—	—	—
Florida State U	8	14	9	12	—	—	—
Florida, U of	7	55	6	9	39	12	0
Fordham U	3	9	3	3	—	—	—
Fort Lewis C	6	4	—	—	—	—	—
Franklin and Marshall C	18	10	—	—	—	—	—
Furman U	10	16	5	—	—	—	—
Geneva C	1	6	—	—	—	—	—
George Mason U	12	4	—	—	—	—	—
George Washington U	12	10	2	4	—	—	—
Georgetown U	15	0	5	9	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Georgia Institute of Tech	25	0	4	14	a		
Georgia State U	7	2	3	—	—	—	—
Georgia, U of	2	46	10	13	—	—	—
Gettysburg C	6	7	—	—	—	—	—
Glassboro State C	11	0	—	—	—	—	—
Gonzaga U	0	7	—	—	—	—	—
Goucher C	3	13	—	—	—	—	—
Grand Valley State C	0	14	—	—	—	—	—
Grinnell C	3	16	—	—	—	—	—
Gustavus Adolphus C	5	12	—	—	—	—	—
Hamilton C	0	9	—	—	—	—	—
Hamline U	7	7	—	—	—	—	—
Hampden-Sydney C	5	7	—	—	—	—	—
Hampton Institute	4	4	—	—	—	—	—
Hartford, U of	1	4	0	—	—	—	—
Hartwick C	1	2	—	—	—	—	—
Harvard U	0	24	21	26	—	—	—
Harvey Mudd C	17	0	—	—	—	—	—
Haverford C	4	8	—	—	—	—	—
Hawaii, U of	19	5	3	6	—	—	—
Hiram C	7	7	—	—	—	—	—
Hobart and William Smith C	1	5	—	—	—	—	—
Hofstra U	9	1	—	—	—	—	—
Hollins C	0	1	—	—	—	—	—
Holy Cross, C of the	24	13	3	—	—	—	—
Hope C	13	16	—	—	—	—	—
Houston, U of	18	0	4	9	47	24	4
Howard U	2	33	6	3	15	—	—
Humboldt State U	4	6	—	—	—	—	—
Idaho State U	6	1	0	—	—	—	—
Idaho, U of	3	3	3	2	a		
Illinois Benedictine C	17	0	—	—	—	—	—
Illinois Institute of Tech	4	0	14	1	a		
Illinois State U	32	0	6	—	—	—	—
Illinois, U of							
Chicago	17	24	15	14	a		
Urbana-Champaign	54	77	23	60	95	20	11
Illinois Wesleyan U	1	5	—	—	—	—	—
Indiana State U	5	1	2	—	—	—	—
Indiana U	37	97	4	24	—	—	—
Indiana U South Bend	2	7	—	—	—	—	—
Indiana U of Pennsylvania	15	2	5	—	—	—	—
Indiana U-Purdue U							
Fort Wayne	4	1	—	—	—	—	—
Indianapolis	1	28	4	—	—	—	—
Iowa State U	7	3	6	22	72	15	3
Iowa, U of	13	0	5	19	20	3	1
Ithaca C	5	1	—	—	—	—	—
Jackson State U	4	8	1	—	—	—	—
James Madison U	5	10	—	—	—	—	—
John Carroll U	8	14	1	—	—	—	—
Johns Hopkins U	12	0	7	7	—	—	—
Juniata C	6	15	—	—	—	—	—
Kalamazoo C	3	19	—	—	—	—	—
Kansas State U	1	8	4	9	31	6	2
Kansas, U of	2	17	0	7	a		
Kean C of New Jersey[c]					—	—	—
Kearney State C	1	8	—	—	—	—	—
Kent State U	7	10	1	9	—	—	—
Kentucky, U of	4	10	5	3	42	5	0
Kenyon C	11	6	—	—	—	—	—
King's C	10	0	—	—	—	—	—
Knox C	1	25	—	—	—	—	—
Lafayette C	6	14	—	—	32	—	—
Lake Forest C	0	4	—	—	—	—	—
Lamar U	9	7	2	—	42	9	0
La Salle C	6	0	—	—	—	—	—
Lawrence U[d]	3	5	18	2	—	—	—
Lebanon Valley C	7	2	—	—	—	—	—
Lehigh U	24	0	13	5	99	20	1
LeMoyne C	17	0	—	—	—	—	—
Lincoln U	0	4	—	—	—	—	—
Long Island U							
Brooklyn Center	2	10	2	—	—	—	—
C. W. Post C	4	1	—	—	—	—	—
Loras C	4	1	—	—	—	—	—
Louisiana State U							
Baton Rouge	11	0	3	9	75	11	4
Shreveport	3	0	—	—	—	—	—
Louisiana Tech U	1	1	0	—	a		
Louisville, U of	6	13	2	1	—	19	1
Lowell, U of	11	2	5	3	42	3	—
Loyola C	7	5	—	—	—	—	—
Loyola Marymount U	3	0	—	—	—	—	—
Loyola U in New Orleans	0	0	—	—	—	—	—
Loyola U of Chicago	6	19	6	4	—	—	—
Luther C	2	8	—	—	—	—	—
Macalester C	4	9	—	—	—	—	—
MacMurray C	0	4	—	—	—	—	—
Maine, U of	1	3	0	0	43	1	1
Manhattan C[e]	10	4	—	—	67	44	—
Manhattanville C	3	0	—	—	—	—	—
Mankato State U	7	4	1	—	—	—	—
Marietta C	6	1	—	—	—	—	—
Marist C	0	6	—	—	—	—	—
Marquette U	11	4	10	3	—	—	—
Marshall U	6	13	7	—	—	—	—
Maryland, U of	21	85	9	22	a		
Maryland Baltimore County, U of	3	8	2	0	—	—	—
Massachusetts Institute of Tech	38	0	7	36	102	56	18
Massachusetts, U of	20	11	10	15	55	8	4
McMurry C	0	3	—	—	—	—	—
McNeese State U	3	0	2	—	—	—	—
Memphis State U	1	5	0	0	—	—	—
Mercer U	0	5	—	—	—	—	—
Merrimack C	10	0	—	—	—	—	—
Metropolitan State C	17	0	—	—	—	—	—
Miami U	14	56	9	5	—	—	—
Miami, U of	3	65	3	2	—	—	—
Michigan State U	14	11	14	36	66	8	1
Michigan Technological U	22	0	3	3	116	3	—
Michigan, U of							
Ann Arbor	44	0	29	14	a		
Dearborn	13	2	—	—	—	—	—
Flint	4	7	—	—	—	—	—
Middle Tennessee State U	3	21	3	—	—	—	—
Middlebury C	0	5	0	—	—	—	—
Midwestern State U	1	7	—	—	—	—	—
Millersville State C	6	9	—	—	—	—	—
Millsaps C	2	15	—	—	—	—	—
Minnesota, U of							
Minneapolis	28	0	5	19	185	15	17
Duluth	13	13	1	—	—	—	—
Mississippi C	1	11	—	—	—	—	—
Mississippi State U	3	4	1	2	37	4	0
Mississippi, U of	1	34	1	3	20	3	0
Missouri, U of							
Columbia	9	12	5	6	74	6	1
Kansas City	10	18	6	4	—	—	—
Rolla	10	0	3	5	86	12	1
St. Louis	18	8	13	3	—	—	—
Missouri Western State C[c]					—	—	—
Monmouth C	1	7	—	—	—	—	—
Montana C of Mineral Science & Tech	0	3	1	—	—	—	—
Montana State U	8	5	5	5	52	8	1
Montana, U of	0	5	1	1	—	—	—
Montclair State C	5	22	4	—	—	—	—
Moorhead State U	0	1	—	—	—	—	—
Moravian C	6	4	—	—	—	—	—
Morehouse C[f]	1	2	11	0	—	—	—
Morgan State U	7	8	—	—	—	—	—
Mount Holyoke C	0	8	3	0	—	—	—
Mount Saint Vincent, C of[e]	1	1	—	—	—	—	—
Muhlenberg C	3	25	—	—	—	—	—
Murray State U	5	17	6	—	—	—	—
Muskingum C	4	8	—	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Nebraska, U of							
Lincoln	6	11	3	14	28	1	0
Omaha	5	3	—	—	—	—	—
Nebraska Wesleyan U	0	8	—	—	—	—	—
Nevada, U of							
Las Vegas	0	9	—	—	—	—	—
Reno	1	5	3	2	—	—	—
New Hampshire, U of	14	5	4	4	a		
New Jersey Institute of Tech[b]	—	—	—	—	96	20	3
New Mexico Highlands U	0	0	4	—	—	—	—
New Mexico Institute of Mining & Tech	6	0	3	—	—	—	—
New Mexico State U	1	10	1	1	26	9	—
New Mexico, U of	15	0	8	6	26	6	3
New Orleans, U of	1	11	2	5	—	—	—
New York U	3	35	12	6	—	—	—
Niagara U	1	10	—	—	—	—	—
North Alabama, U of	5	19	—	—	—	—	—
North Carolina A&T State U	5	0	5	—	—	—	—
North Carolina Central U	1	5	1	—	—	—	—
North Carolina State U	18	3	13	4	74	6	4
North Carolina, U of							
Asheville	3	2	—	—	—	—	—
Chapel Hill	37	99	12	26	—	—	—
Charlotte	1	11	3	—	—	—	—
Greensboro	7	4	3	—	—	—	—
Wilmington	7	5	—	—	—	—	—
North Dakota State U	2	15	6	3	—	—	—
North Dakota, U of	0	8	2	4	16	4	—
North Texas State U	4	3	8	7	—	—	—
Northeast Louisiana U	2	0	3	—	—	—	—
Northeastern U	11	0	11	6	a		
Northern Arizona U	5	43	1	—	—	—	—
Northern Colorado, U of	1	7	1	—	—	—	—
Northern Illinois U	13	9	7	2	—	—	—
Northern Iowa, U of	2	12	0	—	—	—	—
Northern Michigan U	1	4	1	—	—	—	—
Northwest Missouri State U	3	4	—	—	—	—	—
Northwestern State U of Louisiana	0	2	1	—	—	—	—
Northwestern U	17	11	25	28	65	17	8
Norwich U	2	1	—	—	—	—	—
Notre Dame, U of	11	11	6	7	53	11	3
Oakland U	9	6	0	—	—	—	—
Oberlin C	3	15	—	—	—	—	—
Occidental C	1	11	—	—	—	—	—
Ohio Northern U	4	9	—	—	—	—	—
Ohio State U	26	0	28	28	66	16	2
Ohio U	9	6	5	6	16	12	0
Ohio Wesleyan U	2	8	—	—	—	—	—
Oklahoma State U	8	9	2	4	45	14	3
Oklahoma, U of	6	20	4	3	49	15	3
Old Dominion U	9	10	8	—	—	—	—
Oregon State U	8	0	5	4	52	17	1
Oregon, U of	7	20	5	9	—	—	—
Pace U	2	3	—	—	—	—	—
Pacific Lutheran U	0	11	—	—	—	—	—
Pacific, U of the	0	16	3	3	—	—	—
Pennsylvania State U	14	15	8	25	160	15	5
Pennsylvania, U of	8	26	5	25	47	18	7
Philadelphia C of Pharmacy & Science	7	0	2	1	—	—	—
Philadelphia C of Textiles & Science	6	0	—	—	—	—	—
Pittsburg State U	2	5	2	—	—	—	—
Pittsburgh, U of	60	44	9	14	72	15	3
Polytechnic Institute of New York	6	0	9	7	48	9	1
Pomona C	9	4	—	—	—	—	—
Portland State U	0	12	2	1	—	—	—
Pratt Institute[b]	—	—	—	—	9	—	—
Princeton U	11	6	11	21	35	8	12
Providence C	2	5	1	0	—	—	—
Puerto Rico, U of							
Mayaguez	19	24	4	—	73	2	—
Rio Piedras	22	16	5	6	—	—	—
Puget Sound, U of	6	1	2	—	—	—	—
Purdue U	19	16	22	33	122	21	11
Purdue U Calumet	1	0	—	—	—	—	—
Randolph-Macon Woman's C	5	4	—	—	—	—	—
Redlands, U of	0	2	—	—	—	—	—
Reed C	14	4	—	—	—	—	—
Regis C	2	1	—	—	—	—	—
Rensselaer Polytechnic Institute	33	0	17	13	92	12	1
Rhode Island, U of	6	1	4	3	17	1	1
Rice U	5	5	2	11	39	9	1
Richmond, U of	1	12	0	—	—	—	—
Rider C	3	0	—	—	—	—	—
Ripon C	5	1	—	—	—	—	—
Roanoke C	4	4	—	—	—	—	—
Rochester Institute of Tech	6	7	6	—	—	—	—
Rochester, U of	13	9	18	13	45	9	0
Rollins C	0	0	—	—	—	—	—
Roosevelt U	2	0	3	—	—	—	—
Rose-Hulman Institute of Tech	8	0	—	—	a		
Russell Sage C	12	0	—	—	—	—	—
Rutgers U							
New Brunswick	73	12	9	9	77	7	3
Newark C of Arts & Sciences	18	5	8	6	—	—	—
Saginaw Valley State C	4	3	—	—	—	—	—
St. Anselm's C	1	8	—	—	—	—	—
St. Cloud State U	2	6	—	—	—	—	—
St. John Fisher C	7	2	—	—	—	—	—
St. John's U	9	0	8	—	—	—	—
St. Joseph C	0	1	3	—	—	—	—
St. Joseph's U	10	11	12	—	—	—	—
St. Lawrence U	9	21	—	—	—	—	—
St. Louis U	8	51	6	—	—	—	—
St. Mary's C	2	2	—	—	—	—	—
St. Olaf C	2	47	—	—	—	—	—
St. Peter's C	1	2	—	—	—	—	—
St. Thomas, C of	2	8	—	—	—	—	—
Sam Houston State U	13	1	2	—	—	—	—
San Diego State U	10	2	19	3	—	—	—
San Francisco State U	10	16	5	—	—	—	—
San Francisco, U of	3	2	—	—	—	—	—
San Jose State U	20	12	16	—	11	6	—
Santa Clara, U of	7	7	—	—	—	—	—
Scranton, U of	8	18	12	—	—	—	—
Seattle U	4	3	—	—	—	—	—
Seton Hall U	10	1	13	3	—	—	—
Shippensburg State C	8	8	1	—	—	—	—
Siena C	4	0	—	—	—	—	—
Simmons C	1	2	—	—	—	—	—
Skidmore C	0	18	—	—	—	—	—
Slippery Rock State C	0	0	—	—	—	—	—
Smith C	8	1	0	0	—	—	—
Sonoma State U	1	9	—	—	—	—	—
South Carolina, U of	2	19	11	13	29	5	0
South Dakota School of Mines & Tech	17	2	0	—	41	0	—
South Dakota State U	0	23	6	—	—	—	—
South Dakota, U of	3	12	3	—	—	—	—
South Florida, U of	17	59	1	5	a		
Southeast Missouri State U	2	11	2	—	—	—	—
Southeastern Massachusetts U	3	14	1	—	—	—	—
Southern California, U of	14	6	2	10	a		
Southern Illinois U							
Carbondale	10	12	3	6	—	—	—
Edwardsville	2	17	5	—	—	—	—
Southern Methodist U	6	16	1	—	—	—	—
Southern Mississippi, U of	1	10	2	6	—	—	—
Southern Oregon State C	3	3	—	—	—	—	—
Southern University & A&M C	4	0	3	—	—	—	—

	CHEMISTRY				CHEMICAL ENGINEERING		
	Bachelor's, certified						
	Yes	No	M.S.	Ph.D.	B.S.	M.S.	Ph.D.
Southwest Missouri State U	3	20	—	—	—	—	—
Southwest State U	3	7	—	—	—	—	—
Southwest Texas State U	8	1	3	—	—	—	—
Southwestern at Memphis	8	3	—	—	—	—	—
Southwestern Louisiana, U of	0	9	2	—	21	2	—
Southwestern Oklahoma State U	10	4	—	—	—	—	—
Stanford U	28	9	6	20	34	24	7
State U of New York							
Albany	22	3	4	1	—	—	—
Binghamton	5	22	3	4	—	—	—
Buffalo	14	5	3	17	93	21	2
Stony Brook	33	31	2	7	—	—	—
C at Brockport	5	7	—	—	—	—	—
C at Buffalo	10	11	3	—	—	—	—
C at Cortland	3	6	—	—	—	—	—
C at Fredonia	11	10	0	—	—	—	—
C at Geneseo	4	0	1	—	—	—	—
C at New Paltz	11	0	1	—	—	—	—
C at Oneonta	2	20	0	—	—	—	—
C at Oswego	18	0	3	—	—	—	—
C at Plattsburgh	10	11	2	—	—	—	—
C at Potsdam	8	10	1	—	—	—	—
Stephen F. Austin State U	1	15	1	—	—	—	—
Stetson U	1	7	—	—	—	—	—
Stevens Institute of Tech	10	0	13	2	—	—	—
Suffolk U	1	5	—	—	—	—	—
Susquehanna U	4	1	—	—	—	—	—
Swarthmore C	5	6	—	—	—	—	—
Syracuse U	16	7	3	1	27	13	5
Temple U	4	11	6	1	—	—	—
Tennessee Tech U	2	15	1	—	34	7	—
Tennessee, U of							
Knoxville	2	21	6	5	59	12	4
Chattanooga	9	19	—	—	—	—	—
Martin	3	7	—	—	—	—	—
Texas A&I U	4	1	1	—	a		
Texas A&M U	12	9	11	15	127	11	3
Texas Christian U	5	11	0	1	—	—	—
Texas Southern U	22	0	12	—	—	—	—
Texas Tech U	13	8	7	6	50	13	0
Texas, U of							
Arlington	10	16	8	—	—	—	—
Austin	50	0	12	29	102	22	3
Dallas	7	1	1	—	—	—	—
El Paso	14	1	6	—	—	—	—
Texas Woman's U	0	5	0	0	—	—	—
Thiel C	2	6	—	—	—	—	—
Thomas More C	3	0	—	—	—	—	—
Toledo, U of	0	16	4	0	27	7	—
Towson State U	3	5	—	—	—	—	—
Trenton State C	16	0	—	—	—	—	—
Trinity C	11	10	0	—	—	—	—
Trinity U	1	5	1	—	—	—	—
Tri-State U[b]	—	—	—	—	a		
Tufts U	0	25	1	3	32	3	0
Tulane U of Louisiana	0	10	1	0	26	3	0
Tulsa, U of	0	0	—	—	22	10	2
Tuskegee Institute	0	3	2	—	—	—	—
Union C	3	15	0	—	—	—	—
U.S. Air Force Academy	3	6	—	—	—	—	—
U.S. Naval Academy	30	0	—	—	—	—	—
Ursinus C	10	12	—	—	—	—	—
Utah State U	4	0	6	0	—	—	—
Utah, U of	2	22	3	13	36	2	5
Valparaiso U	2	40	—	—	—	—	—
Vanderbilt U	2	22	2	2	a		
Vassar C	1	4	0	—	—	—	—
Vermont, U of	18	0	0	5	—	—	—
Villanova U	10	0	5	3	29	6	—
Virginia Commonwealth U	7	24	1	3	—	—	—
Virginia Military Institute	11	0	—	—	—	—	—
Virginia Polytechnic Institute & State U	6	10	6	12	90	7	1
Virginia, U of	11	72	8	12	35	17	2
Wabash C	15	0	—	—	—	—	—
Wagner C	5	9	—	—	—	—	—
Wake Forest U	7	17	1	0	—	—	—
Washburn U of Topeka	4	5	—	—	—	—	—
Washington C	4	0	—	—	—	—	—
Washington and Jefferson C	2	22	—	—	—	—	—
Washington and Lee U	2	11	—	—	—	—	—
Washington State U	5	12	4	7	26	4	0
Washington U	2	25	10	8	56	15	7
Washington, U of	46	19	13	15	76	16	3
Wayne State U	21	22	4	12	38	20	3
Waynesburg C	6	3	—	—	—	—	—
Weber State C	6	3	—	—	—	—	—
Wellesley C	0	16	—	—	—	—	—
Wesleyan U	9	9	2	0	—	—	—
West Chester State C	9	12	3	—	—	—	—
West Florida, U of	10	0	—	—	—	—	—
West Texas State U	1	20	2	—	—	—	—
West Virginia Institute of Tech	4	0	—	—	12	0	—
West Virginia State C	4	7	—	—	—	—	—
West Virginia U	12	39	8	7	31	4	3
Western Illinois U	5	10	4	—	—	—	—
Western Kentucky U	2	14	5	—	—	—	—
Western Maryland C	1	4	—	—	—	—	—
Western Michigan U	7	15	1	2	—	—	—
Western New England C	2	1	—	—	—	—	—
Western Washington U	15	23	1	—	—	—	—
Westminster C	0	5	—	—	—	—	—
Wheaton C (Illinois)	2	12	—	—	—	—	—
Wheaton C (Massachusetts)	2	6	—	—	—	—	—
Wheeling C	1	0	—	—	—	—	—
Whitman C	4	8	—	—	—	—	—
Whittier C	1	4	—	—	—	—	—
Wichita State U	9	5	2	1	—	—	—
Widener C	2	0	—	—	—	—	—
Wilkes C	4	0	—	—	—	—	—
Willamette U	1	4	—	—	—	—	—
William Paterson C of New Jersey	3	0	—	—	—	—	—
William and Mary, C of	36	5	6	—	—	—	—
Williams C	2	35	—	—	—	—	—
Wisconsin, U of							
Eau Claire	4	9	—	—	—	—	—
Green Bay	2	4	—	—	—	—	—
La Crosse	3	17	—	—	—	—	—
Madison	9	20	13	50	99	15	15
Milwaukee	2	20	3	4	—	—	—
Oshkosh	5	6	0	—	—	—	—
Parkside	2	6	—	—	—	—	—
Platteville	0	4	—	—	—	—	—
River Falls	3	8	—	—	—	—	—
Stevens Point	6	5	—	—	—	—	—
Superior	1	4	—	—	—	—	—
Wittenberg U	0	8	—	—	—	—	—
Wooster, C of	8	25	—	—	—	—	—
Worcester Polytechnic Institute	4	5	2	1	53	10	0
Wright State U	20	14	15	—	—	—	—
Wyoming, U of	2	3	1	4	18	5	0
Xavier U	6	8	3	—	—	—	—
Xavier U of Louisiana	4	25	—	—	—	—	—
Yale U	16	2	24	16	—	—	—
Youngstown State U	6	28	2	—	38	—	—
TOTALS	**4179**	**5687**	**1645**	**1683**	**5983**	**1171**	**293**

a Data not submitted. b Listed on basis of accreditation by AIChE-ABET. c Added in 1982. d Master's and Ph.D. degrees given by the Institute of Paper Chemistry. e The chemistry programs at Mount Saint Vincent College and Manhattan College are integrated into a combined department with all instruction in chemistry located at Manhattan College. f Master's degrees given by Atlanta University. **Note:** For brevity, "B.S." and "M.S." are used to denote all bachelor's and master's degrees, respectively, in each column.